Complete Summary

GUIDELINE TITLE

Plexopathy.

BIBLIOGRAPHIC SOURCE(S)

Bowen B, Seidenwurm DJ, Davis PC, Brunberg JA, De La Paz RL, Dormont PD, Hackney DB, Jordan JE, Karis JP, Mukherji SK, Turski PA, Wippold FJ III, Zimmerman RD, McDermott MW, Sloan MA, Expert Panel on Neurologic Imaging. Plexopathy. [online publication]. Reston (VA): American College of Radiology (ACR); 2006. [44 references]

GUIDELINE STATUS

This is the current release of the guideline.

The appropriateness criteria are reviewed annually and updated by the panels as needed, depending on introduction of new and highly significant scientific evidence.

** REGULATORY ALERT **

FDA WARNING/REGULATORY ALERT

Note from the National Guideline Clearinghouse: This guideline references a drug(s) for which important revised regulatory and/or warning information has been released.

- May 23, 2007, Gadolinium-based Contrast Agents: The addition of a boxed warning and new warnings about the risk of nephrogenic systemic fibrosis (NSF) to the full prescribing information for all gadolinium-based contrast agents (GBCAs).

COMPLETE SUMMARY CONTENT

** REGULATORY ALERT **
SCOPE
METHODOLOGY - including Rating Scheme and Cost Analysis
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INSTITUTE OF MEDICINE (IOM) NATIONAL HEALTHCARE QUALITY REPORT CATEGORIES

IDENTIFYING INFORMATION AND AVAILABILITY
DISCLAIMER

SCOPE

DISEASE/CONDITION(S)

Plexopathy

GUIDELINE CATEGORY

Diagnosis
Evaluation

CLINICAL SPECIALTY

Family Practice
Internal Medicine
Neurology
Oncology
Radiology
Surgery

INTENDED USERS

Health Plans
Hospitals
Managed Care Organizations
Physicians
Utilization Management

GUIDELINE OBJECTIVE(S)

To evaluate the appropriateness of initial radiologic examinations for patients with plexopathy

TARGET POPULATION

Patients with plexopathy

INTERVENTIONS AND PRACTICES CONSIDERED

1. Magnetic resonance imaging (MRI) without and with contrast
    - Neck
    - Chest
    - Upper extremity
    - Abdomen
    - Pelvis
2. Computed tomography (CT), without and with contrast
    - Neck

- Chest
- Upper extremity
- Abdomen
- Pelvis

3. X-ray
    - Chest
    - Cervical spine
    - Myelography
    - Thoracic spine
    - Lumbosacral spine
    - Pelvis
4. Fluorodeoxyglucose positron emission tomography (FDG-PET), whole body
5. CT myelography
    - Cervical
    - Thoracic spine

MAJOR OUTCOMES CONSIDERED

Utility of radiologic examinations in differential diagnosis

METHODOLOGY

METHODS USED TO COLLECT/SELECT EVIDENCE

Searches of Electronic Databases

DESCRIPTION OF METHODS USED TO COLLECT/SELECT THE EVIDENCE

The guideline developer performed literature searches of peer-reviewed medical journals and the major applicable articles were identified and collected.

NUMBER OF SOURCE DOCUMENTS

The total number of source documents identified as the result of the literature search is not known.

METHODS USED TO ASSESS THE QUALITY AND STRENGTH OF THE EVIDENCE

Weighting According to a Rating Scheme (Scheme Not Given)

RATING SCHEME FOR THE STRENGTH OF THE EVIDENCE

Not stated

METHODS USED TO ANALYZE THE EVIDENCE

Systematic Review with Evidence Tables

DESCRIPTION OF THE METHODS USED TO ANALYZE THE EVIDENCE

One or two topic leaders within a panel assume the responsibility of developing an evidence table for each clinical condition, based on analysis of the current literature. These tables serve as a basis for developing a narrative specific to each clinical condition.

METHODS USED TO FORMULATE THE RECOMMENDATIONS

Expert Consensus (Delphi)

DESCRIPTION OF METHODS USED TO FORMULATE THE RECOMMENDATIONS

Since data available from existing scientific studies are usually insufficient for meta-analysis, broad-based consensus techniques are needed for reaching agreement in the formulation of the appropriateness criteria. The American College of Radiology (ACR) Appropriateness Criteria panels use a modified Delphi technique to arrive at consensus. Serial surveys are conducted by distributing questionnaires to consolidate expert opinions within each panel. These questionnaires are distributed to the participants along with the evidence table and narrative as developed by the topic leader(s). Questionnaires are completed by participants in their own professional setting without influence of the other members. Voting is conducted using a scoring system from 1-9, indicating the least to the most appropriate imaging examination or therapeutic procedure. The survey results are collected, tabulated in anonymous fashion, and redistributed after each round. A maximum of three rounds is conducted and opinions are unified to the highest degree possible. Eighty percent agreement is considered a consensus. This modified Delphi technique enables individual, unbiased expression, is economical, easy to understand, and relatively simple to conduct.

If consensus cannot be reached by the Delphi technique, the panel is convened and group consensus techniques are utilized. The strengths and weaknesses of each test or procedure are discussed and consensus reached whenever possible. If "No consensus" appears in the rating column, reasons for this decision are added to the comment sections.

RATING SCHEME FOR THE STRENGTH OF THE RECOMMENDATIONS

Not applicable

COST ANALYSIS

A formal cost analysis was not performed and published cost analyses were not reviewed.

METHOD OF GUIDELINE VALIDATION

Internal Peer Review

DESCRIPTION OF METHOD OF GUIDELINE VALIDATION

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

RECOMMENDATIONS

MAJOR RECOMMENDATIONS

ACR Appropriateness Criteria®

Clinical Condition: Plexopathy

Variant 1: Brachial -- sudden onset.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, neck, and/or chest, and/or upper extremity, without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
MRI, neck, and/or chest, and/or upper extremity, without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, neck, and/or chest, and/or upper extremity, without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, neck, and/or chest, and/or upper extremity, without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
X-ray, chest	3	
X-ray, cervical spine	3	
FDG-PET, whole body	1	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 2: Brachial -- chronic.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, neck, and/or chest, and/or upper extremity, without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
MRI, neck, and/or chest, and/or upper extremity, without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, neck, and/or chest, and/or upper extremity, without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, neck, and/or chest, and/or upper extremity, without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
X-ray, cervical spine	4	
X-ray, chest	3	
FDG-PET, whole body	2	May be appropriate if malignancy suspected.
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 3: Brachial -- post-traumatic, nonacute.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, neck, and/or chest, and/or upper extremity, without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
MRI, neck, and/or chest, and/or upper extremity, without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT myelography,	6	

Radiologic Procedure	Appropriateness Rating	Comments
cervical and/or thoracic spine		
X-ray, myelography, cervical and/or thoracic spine	5	Usually performed with CT.
CT, neck, and/or chest, and/or upper extremity, without contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, neck, and/or chest, and/or upper extremity, without and with contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
X-ray, chest	3	
X-ray, cervical spine	3	
FDG-PET, whole body	1	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 4: Brachial -- cancer patient. No history of local radiation therapy.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, neck, and/or chest, and/or upper extremity, without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
MRI, neck, and/or chest, and/or upper extremity, without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
FDG-PET, whole body	7	May be useful for staging and characterizing local lesion.
CT, neck, and/or chest, and/or upper	5	One or more anatomically contiguous studies may be appropriate depending

Radiologic Procedure	Appropriateness Rating	Comments
extremity, without and with contrast		on clinical circumstances.
CT, neck, and/or chest, and/or upper extremity, without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
X-ray, chest	4	
X-ray, cervical spine	3	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 5: Brachial -- cancer patient, post-radiation therapy.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, neck, and/or chest, and/or upper extremity, without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
MRI, neck, and/or chest, and/or upper extremity, without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
FDG-PET, whole body	7	Best imaging tool to distinguish between tumor recurrence and radiation plexopathy.
CT, neck, and/or chest, and/or upper extremity, without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, neck, and/or chest, and/or upper extremity, without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
X-ray, chest	4	

Radiologic Procedure	Appropriateness Rating	Comments
X-ray, cervical spine	3	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 6: Lumbar -- sudden onset.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, abdomen and/or pelvis, without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
MRI, abdomen and/or pelvis, without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, abdomen and/or pelvis, without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, abdomen and/or pelvis, without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
X-ray, lumbosacral spine	3	
FDG-PET, whole body	1	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 7: Lumbar -- chronic.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, abdomen and/or	8	One or more anatomically contiguous

Radiologic Procedure	Appropriateness Rating	Comments
pelvis, without and with contrast		studies may be appropriate depending on clinical circumstances.
MRI, abdomen and/or pelvis, without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, abdomen and/or pelvis, without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, abdomen and/or pelvis, without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
X-ray, lumbosacral spine	4	
FDG-PET, whole body	2	May be appropriate if malignancy suspected.
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 8: Lumbar -- post-traumatic, nonacute.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, abdomen and/or pelvis, without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
MRI, abdomen and/or pelvis, without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, abdomen and/or pelvis, without contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, abdomen and/or pelvis, without and with contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
X-ray, lumbosacral	3	

Radiologic Procedure	Appropriateness Rating	Comments
spine		
FDG-PET, whole body	1	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 9: Lumbar -- cancer patient. No history of local radiation therapy.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, abdomen and/or pelvis, without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
MRI, abdomen and/or pelvis, without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
FDG-PET, whole body	7	May be useful for staging and characterizing local lesion.
CT, abdomen and/or pelvis, without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, abdomen and/or pelvis, without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
X-ray, lumbosacral spine	3	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 10: Lumbar -- cancer patient, post-radiation therapy.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, abdomen and/or pelvis, without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
MRI, abdomen and/or pelvis, without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
FDG-PET, whole body	7	Best imaging tool to distinguish between tumor recurrence and radiation plexopathy.
CT, abdomen and/or pelvis, without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, abdomen and/or pelvis, without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
X-ray, lumbosacral spine	3	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 11: Sacral -- sudden onset.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, abdomen and/or pelvis, without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
MRI, abdomen and/or pelvis, without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, abdomen and/or pelvis, without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, abdomen and/or pelvis, without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.

Radiologic Procedure	Appropriateness Rating	Comments
X-ray, lumbosacral spine	3	
X-ray, pelvis	3	
FDG-PET, whole body	1	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 12: Sacral -- chronic.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, abdomen and/or pelvis, without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
MRI, abdomen and/or pelvis, without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, abdomen and/or pelvis, without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, abdomen and/or pelvis, without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
X-ray, lumbosacral spine	4	
X-ray, pelvis	3	
FDG-PET, whole body	2	May be appropriate if malignancy suspected
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 13: Sacral -- post-traumatic, nonacute.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, abdomen and/or pelvis, without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
MRI, abdomen and/or pelvis, without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, abdomen and/or pelvis, without contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, abdomen and/or pelvis, without and with contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
X-ray, lumbosacral spine	3	
X-ray, pelvis	3	
FDG-PET, whole body	1	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 14: Sacral -- cancer patient. No history of local radiation therapy.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, abdomen and/or pelvis, without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
MRI, abdomen and/or pelvis, without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
FDG-PET, whole body	7	May be useful for staging and characterizing local lesion.
CT, abdomen and/or pelvis, without and	5	One or more anatomically contiguous studies may be appropriate depending

Radiologic Procedure	Appropriateness Rating	Comments
with contrast		on clinical circumstances.
CT, abdomen and/or pelvis, without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
X-ray, lumbosacral spine	3	
X-ray, pelvis	3	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 15: Sacral -- cancer patient, post-radiation therapy.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, abdomen and/or pelvis, without and with contrast	8	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
MRI, abdomen and/or pelvis, without contrast	7	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
FDG-PET, whole body	7	Best imaging tool to distinguish between tumor recurrence and radiation plexopathy.
CT, abdomen and/or pelvis, without and with contrast	5	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
CT, abdomen and/or pelvis, without contrast	4	One or more anatomically contiguous studies may be appropriate depending on clinical circumstances.
X-ray, lumbosacral spine	3	
X-ray, pelvis	3	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9**		

Radiologic Procedure	Appropriateness Rating	Comments
1 = Least appropriate 9 = Most appropriate		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Summary of Literature Review

Introduction

Plexopathy is the manifestation of abnormal neurological findings by an anatomically defined network of nerves, which are derived from the ventral rami of a set of spinal nerves. Pain (shoulder and arm, or back and leg) with a neuropathic character, dysethesias, burning or electric sensation, occurring in more than one peripheral nerve distribution is characteristic of plexopathy. Pain that radiates in a dermatomal distribution and sensory loss or motor loss in a spinal nerve root distribution are characteristic of radiculopathy.

Magnetic resonance imaging (MRI) of peripheral nerves at high spatial resolution, with and without fat suppression, has been shown to detect features of intraneural anatomy not previously seen on diagnostic imaging studies and to localize pathologic lesions in conditions where electrophysiologic and physical findings are nonspecific or nonlocalizing.

The use of phased arrays and integrated arrays of radiofrequency (RF) coils for dedicated brachial plexus imaging has made it possible to directly evaluate the plexus components—roots, trunks, divisions, and cords—and frequently to distinguish between intrinsic and extrinsic pathological changes.

Evaluation of the plexus focuses on evidence for a mass lesion infiltrating perineural fat and assessment of the intrinsic magnetic resonance (MR) features of nerves, such as signal intensity on short tau inversion recovery (STIR) or fat-saturated T2-weighted fast-spin-echo (FSE) images, the appearance of the intraneural fascicular pattern, and/or the pattern of post-contrast enhancement on fat-saturated T1-weighted images. If an MRI is of diagnostic quality, an accompanying CT study or positron emission tomography (PET) study is only rarely necessary. An exception may be made for post-traumatic brachial plexopathy, for which MRI and post-myelographic CT are complementary in the evaluation of foraminal, paraspinal, and peripheral plexus injuries.

Mastery of anatomy and availability of anatomical references are useful in interpreting studies of the brachial and lumbosacral plexus.

MR Techniques and Image Contrast

The goal is usually to image either the right or left brachial plexus at high spatial resolution; a bilateral examination may also be employed. A comprehensive MRI study of the brachial plexus extends from the roots and trunks, located in the

supraclavicular region, to the terminal branches of the cords, located in the infraclavicular region just lateral to the pectoralis minor muscle. For optimal results, the MRI study is targeted to a specific region of the plexus by a careful clinical examination and electrophysiological studies.

Pulse Sequences

At field strengths of 1.0 to 1.5 tesla, the plexus is commonly evaluated based on its appearance on T1- and T2-weighted images. Conventional two-dimensional (2D) spin-echo or FSE sequences are used to generate the T1-weighted images, although some investigators prefer T1-weighted 3D gradient-echo images. The T1-weighted images display regional anatomy, including the various muscles, blood vessels, and nerves outlined by tissue fat planes. The 2D T2- weighted images are generated with FSE sequences and are useful to detect pathologic changes within components of the plexus. Since abnormal intraneural signal from one component, such as a root or a cord, of the plexus may be obscured by adjacent fat signal, fat suppression is used. The two most common methods are STIR and frequency-selective saturation of the fat resonance.

Contrast-enhanced images of the plexus are obtained routinely in patients being evaluated for suspected neoplasm, radiation injury, inflammation, or abscess formation, and following peripheral nerve surgery. In addition to these indications, contrast-enhanced images have also proven useful in some cases of nerve entrapment and stretch injury. In cases of acute severe traumatic nerve injury and simple compressive neuropathy, a noncontrast exam can be sufficient.

MR Imaging: Normal versus Abnormal Plexus

Abnormal plexus findings include the following: loss of fat planes around all or part of a plexus component, diffuse or focal enlargement of a component (especially, the presence of an eccentric or nodular mass), marked hyperintensity on T2-weighted images and/or enhancement on T1-weighted images with fat suppression. An altered fascicular pattern is also abnormal, although this may not always be apparent. Demonstration of a fascicular pattern may be more difficult for plexus components than for individual peripheral nerves, like the sciatic and tibial nerves, because of the lower spatial resolution of plexus images and because of the difficulty in obtaining true cross-sectional views of most plexus components.

Indications for MR Imaging of the Brachial Plexus

A 1994 study found conventional spin-echo MRI without gadolinium to be 63% sensitive, 100% specific, and 77% accurate compared to clinicopathologic results in the evaluation of 43 patients with suspected brachial plexopathy. Accuracy increased to 88% when evaluation involved only the subset of patients (n=34) with neoplastic or traumatic disorders. With current high-resolution MRI and the use of gadolinium contrast agents, accuracy is likely to be increased further.

Mass Involving the Plexus

MRI can often determine whether a mass is intrinsic or extrinsic to a component nerve of the plexus and, for extrinsic masses, determine the site of the displaced and compressed nerve fibers prior to surgical intervention. Such information is valuable in the diagnosis and management of patients with plexopathy due to neoplastic processes (such as nerve sheath tumors, metastases, direct extension of non-neurogenic primary tumor, and lymphoma) or benign processes (such as aggressive fibromatosis [desmoid tumor] and nodular fasciitis). In a series of 48 reported tumors, 44% were benign and included fibromatosis (most common), lipoma, myositis ossificans, ganglioneuroma, hemangioma, and lymphangioma. The information from MRI aids in preoperative planning and may help to shorten the surgical procedure.

High-resolution coronal and sagittal images of the symptomatic brachial plexus are especially beneficial in cases where clinical examination and lower resolution imaging studies (covering both right and left plexuses in a single field of view are not able to distinguish whether a patient's symptoms are due to recurrent tumor, to postoperative or post-treatment changes associated with scarring, or to compressive neuropathy resulting from regional deformity. In patients with plexopathy and Horner's syndrome, axial images are useful to demonstrate paraspinal extension of tumor. If a mass is contiguous with the longus colli muscle, the sympathetic chain is usually invaded. (For lumbosacral imaging, high-resolution coronal and axial images of the bilateral lumbar plexus or sacral plexus are typically obtained).

Brachial plexopathy caused by metastatic disease is most often seen in patients with carcinoma of the breast or lung. Metastases from breast carcinoma are the most common and involve the plexus mainly by lymphatic spread. Other primary malignancies, such as melanoma, gastrointestinal or genitourinary carcinomas, that metastasized to lymph nodes, soft tissue, or bone and resulted in plexopathy, have been reported.

Lymphoma can involve the plexus in two ways. First, enlarged lymph nodes can compress and/or infiltrate the plexus. Second, neurolymphomatosis, which is a rare manifestation of lymphoma primarily involving the peripheral nerves, can affect the plexus.

The differential diagnosis of infiltrative lesions of the plexus also includes soft tissue tumors, such as sarcomas and fibromatosis. Aggressive fibromatosis is a benign fibroblastic proliferation that occurs in the deep soft tissues, mimics fibrosarcoma, but does not metastasize. It tends to invade or surround muscles, tensions, nerves, and vessels and to recur locally following excision.

The most common neurogenic tumors of the plexus are the benign nerve sheath tumors: neurofibroma (50% to 65%), and schwannoma (18% to 20%). Malignant peripheral nerve sheath tumors account for 14% of the neurogenic tumors. Nerve sheath tumors may involve any component of the plexus, although the roots are the most frequent site.

Malignant peripheral nerve sheath tumors (MPNSTs) occur less frequently than benign tumors, and are found mainly in patients with neurofibromatosis or a history of previous radiation therapy to the brachial plexus region.

Traumatic Injury

Injury to a peripheral nerve due to trauma can range from disruption of axonal conduction with preservation of anatomical continuity of the connective tissue sheaths (neurapraxic injury) to severed nerve with complete loss of continuity of the nerve (neurotmesis injury). By demonstrating the location and severity of injury and the morphology of the injured nerve, high-resolution MRI complements the electrophysiologic studies in determining the exact site and type of nerve injury, and the potential for surgical treatment versus spontaneous recovery. In addition, MRI can show the relationship of the intact nerve to posttraumatic lesions such as spindle, lateral, and stump neuromas, as well as focal or diffuse perineural fibrosis.

Brachial, lumbar, or sacral plexopathy following trauma can result from compression, stretching, or laceration of plexal components, perineural fibrosis, or avulsion of nerve roots from the spinal cord.

It is important to distinguish intraspinal nerve root avulsion (preganglionic lesion) from brachial plexus interruption (postganglionic lesion) since the surgical treatment differs. Nerve root avulsion cannot be repaired directly, and neurotization by nerve-crossing using the intercostal nerves and/or spinal accessory nerve has been recommended. Brachial plexus interruption can be treated by local repair, and nerve grafting is the usual method of plexus reconstruction. Differentiation of nerve root avulsion from plexus injury is aided by electromyography (EMG) studies, since abnormalities of the paraspinal muscles indicate that an injury is proximal to the plexal trunks. Somatosensory evoked potentials have been routinely used to diagnose nerve root avulsion; however, because these do not enable one to discriminate between incomplete avulsion and intact roots, or between intraforminal root avulsion and rootlet avulsion from the spinal cord, the inclusion of imaging studies (myelography, CT myelography, high-resolution MRI, and MR myelography) in the diagnostic evaluation has been recommended.

The two major causes of cervical nerve root avulsion are motorcycle accidents and traumatic delivery at birth. In the detection of nerve root avulsion, some studies found that myelography/CT myelography was the most accurate approach (>90%), confirming separate reports of the reliable demonstration of root avulsion with CT myelography and a 92% accuracy of MR myelography compared to CT myelography. Other studies, however, found that myelography/CT myelography and MRI achieved similar accuracy. In the detection of traumatic pseudomeningocele, conventional spin-echo MRI is equivalent to CT myelography, which is more accurate than myelography. For overall characterization of traumatic brachial plexopathy, MRI has an advantage over CT and myelography, because it is better able to show plexus lesions (postganglionic), in addition to detecting pseudomeningocele. Examples of posttraumatic lesions of the plexus that have been demonstrated on spin-echo images include neuromas (tangles of regenerating nerve fibers), focal or diffuse fibrosis, and masses that compress or stretch the plexus, such as hematoma, clavicular fracture, and humeral dislocation.

Entrapment Syndromes

Guided to the location of entrapment/compression by the clinical and neurological examination, the MRI study is used to detect objective findings of nerve compression. The brachial plexus and/or the subclavian/axillary artery or vein encounter three possible sites of compression along their course: the interscalene triangle, the costoclavicular space between the first thoracic rib and the clavicle, and the retropectoralis minor space posterior to the pectoralis minor muscle near its insertion on the coracoid process. There is some disagreement regarding the value of MRI in diagnosing neurologic or combined neurovascular thoracic outlet syndrome (TOS).

Post-treatment Evaluation

Patients with a history of cancer and clinical evidence of plexopathy following radiation therapy may have, predominantly or exclusively, recurrent tumor or radiation-induced plexopathy. Imaging features that favor recurrent tumor are nonuniform, asymmetric diffuse, or focal enlargement, especially the presence of an eccentric mass with post-contrast enhancement. Imaging features that favor post-radiation injury of the brachial plexus are diffuse, uniform, symmetric swelling and T2 hyperintensity of the plexus nerves within the radiation field. Diffuse, uniform post-contrast enhancement for months to years after treatment may also result from radiation injury. Radiation fibrosis often has low signal intensity on T1-weighted and T2-weighted images, and this may represent the more common appearance for chronic radiation injury, although a correlation between the time interval following radiation therapy and T2 signal intensity has not been reported.

When diffuse enlargement, T2 hyperintensity, and post-contrast enhancement of the plexus (as well as surrounding tissues) are present on MRI of patients with a history of breast cancer and radiation therapy, differentiation between radiation injury and local/regional recurrent cancer with axillary/supraclavicular metastases may not be possible. Preliminary results suggest that Flourine-18-2-fluoro-2-deoxy-D-glucose (FDG) PET helps to confirm metastases in patients with indeterminate MRI findings and is useful for depicting metastases outside the axilla.

Miscellaneous

When the clinical examination does not reveal an etiology for the patient's neuropathy, MRI may identify a focal or diffuse peripheral nerve or plexus structural abnormality, such as occurs in chronic inflammatory demyelinating polyneuropathy (CIDP), multifocal motor neuropathy (MMN), hereditary hypertrophic motor and sensory neuropathies (HMSN), and inflammatory pseudotumor. Idiopathic brachial plexus neuritis, or plexitis, presents with sudden onset of severe, constant pain in the lateral neck, shoulder, scapula, or upper arm. Involvement is bilateral in 10% to 30% of cases. The pain is exacerbated by arm or shoulder movement. In one study, 4 of 64 consecutive patients who underwent MRI for suspected brachial plexus abnormalities had a clinical diagnosis of idiopathic or viral plexitis. In all four patients, spin-echo MRI findings were normal. Another study reported a case of brachial neuritis in which the nerves of the plexus were diffusely enlarged and hyperintense on T2-weighted images. These findings were attributed to inflammation and edema, but not corroborated by subsequent imaging or other methods.

Conclusion

High-resolution MRI of peripheral nerves and nerve plexuses is an area of rapidly growing clinical interest and importance. The number of studies performed is rapidly increasing in response to the need for more detailed in vivo information about neuropathic changes and regional neural anatomy prior to treatment planning by peripheral nerve specialists. Specific information gained from peripheral nerve imaging studies is being used to determine need for biopsy or surgical treatment. In patients with small tumors, peripheral nerve imaging has proven useful in planning the surgical approach and in predicting the prognosis for preservation of nerve function postoperatively. In cases of traumatic nerve injury, MRI results are being considered as part of the clinical assessment regarding 1) the likelihood of spontaneous recovery versus the need for surgical repair, and 2) the progression of nerve recovery postoperatively.

Abbreviations

- CT, computed tomography
- FDG-PET, fluorodeoxyglucose positron emission tomography
- MRI, magnetic resonance imaging

CLINICAL ALGORITHM(S)

Algorithms were not developed from criteria guidelines.

EVIDENCE SUPPORTING THE RECOMMENDATIONS

TYPE OF EVIDENCE SUPPORTING THE RECOMMENDATIONS

The recommendations are based on analysis of the current literature and expert panel consensus.

BENEFITS/HARMS OF IMPLEMENTING THE GUIDELINE RECOMMENDATIONS

POTENTIAL BENEFITS

Selection of appropriate radiologic imaging procedures for evaluation of patients with plexopathy

POTENTIAL HARMS

Not stated

QUALIFYING STATEMENTS

QUALIFYING STATEMENTS

An American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging

examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those exams generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

IMPLEMENTATION OF THE GUIDELINE

DESCRIPTION OF IMPLEMENTATION STRATEGY

An implementation strategy was not provided.

IMPLEMENTATION TOOLS

Personal Digital Assistant (PDA) Downloads

For information about availability, see the "Availability of Companion Documents" and "Patient Resources" fields below.

INSTITUTE OF MEDICINE (IOM) NATIONAL HEALTHCARE QUALITY REPORT CATEGORIES

IOM CARE NEED

Getting Better
Living with Illness

IOM DOMAIN

Effectiveness

IDENTIFYING INFORMATION AND AVAILABILITY

BIBLIOGRAPHIC SOURCE(S)

Bowen B, Seidenwurm DJ, Davis PC, Brunberg JA, De La Paz RL, Dormont PD, Hackney DB, Jordan JE, Karis JP, Mukherji SK, Turski PA, Wippold FJ III, Zimmerman RD, McDermott MW, Sloan MA, Expert Panel on Neurologic Imaging.

Plexopathy. [online publication]. Reston (VA): American College of Radiology (ACR); 2006. [44 references]

ADAPTATION

Not applicable: The guideline was not adapted from another source.

DATE RELEASED

2006

GUIDELINE DEVELOPER(S)

American College of Radiology - Medical Specialty Society

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GUIDELINE COMMITTEE

Committee on Appropriateness Criteria, Expert Panel on Neurologic Imaging

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FINANCIAL DISCLOSURES/CONFLICTS OF INTEREST

Not stated

GUIDELINE STATUS

This is the current release of the guideline.

The appropriateness criteria are reviewed annually and updated by the panels as needed, depending on introduction of new and highly significant scientific evidence.

GUIDELINE AVAILABILITY

Electronic copies: Available in Portable Document Format (PDF) from the American College of Radiology (ACR) Web site.

ACR Appropriateness Criteria® *Anytime*, *Anywhere*™ (PDA application). Available from the ACR Web site.

Print copies: Available from the American College of Radiology, 1891 Preston White Drive, Reston, VA 20191. Telephone: (703) 648-8900.

AVAILABILITY OF COMPANION DOCUMENTS

The following is available:

- ACR Appropriateness Criteria®. Background and development. Reston (VA): American College of Radiology; 2 p. Electronic copies: Available in Portable Document Format (PDF) from the American College of Radiology (ACR) Web site.

PATIENT RESOURCES

None available

NGC STATUS

This NGC summary was completed by ECRI Institute on April 25, 2007. This summary was updated by ECRI Institute on June 20, 2007 following the U.S. Food and Drug Administration (FDA) advisory on gadolinium-based contrast agents.

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